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INTRODUCTION TO APRIL 1984 ISSUE OF THE CEEE TECHNICAL PROGRESS BULLETIN

This is the third issue of a quarterly abstract journal covering the work of the National Bureau of Standards Center for Electronics and Electrical Engineering. This issue of the CEEE Technical Progress Bulletin covers the second quarter of calendar year 1983.

ORGANIZATION: Abstracts and citations are arranged by technical topic as identified in the table of contents and alphabetically by first author under each subheading within each topic. Each abstract ends with a telephone number of the individual to contact for more information on the topic; unless otherwise noted, this individual is the first author. Each citation ends with identification of the issue of the Technical Progress Bulletin in which the associated abstract appeared. This issue also includes a calendar of Center conferences and workshops for the remainder of calendar year 1984, an announcement of newly released standard reference materials, and a list of sponsors of the work. SPECIAL NOTE: Because the four issues covering calendar year 1983 are later than intended, the contents of these issues will differ from the original plan of providing abstracts for all papers approved by NBS in a quarter as follows: Each issue will contain (1) abstracts of papers approved for publication by NBS for the appropriate quarter and not subsequently published until calendar year 1984, (2) abstracts of papers approved and published during the quarter, and (3) citations for papers published during the quarter, but for which abstracts have appeared in an earlier issue of the Technical Progress Bulletin. Items in category (1) appear under the subheading "Approved for Publication"; items in categories (2) and (3) appear under the subheading "Recently Published."

Center for Electronics and Electrical Engineering: Center programs provide national reference standards, measurement methods, supporting theory and data, and traceability to national standards.

The metrological products of these programs aid economic growth by promoting equity and efficiency in the marketplace, by removing metrological barriers to improved productivity and innovation, by increasing U. S. competitiveness in international markets through facilitation of compliance with international agreements, and by providing technical bases for the development of voluntary standards for domestic and international trade. These metrological products also aid in the development of rational regulatory policy and promote efficient functioning of technical programs of the Government.

The work of the Center is divided into two major programs: the Semiconductor Technology Program, carried out by the Semiconductor Materials and Processes and Semiconductor Devices and Circuits Divisions in Gaithersburg, MD, and the Signals and Systems Metrology Program, carried out by the Electrosystems Division in Gaithersburg and the Electromagnetic Fields and Electromagnetic Technology Divisions in Boulder, CO. Key contacts in the Center are given on the back cover; readers are encouraged to contact any of these individuals for further information.

Previous special issues: Two special issues of the Technical Progress Bulletin have been published with abstracts for the Signals and Systems Program only, NBSIR 83-2719-1, covering October 1981 through March 1982 and NBSIR 83-2719-2, covering April 1982 through September 1982. NBSIR 82-2636, a special issue of the Semiconductor Technology Program Progress Briefs published in January 1983, listed abstracts of publications from that Program for Federal fiscal year 1982 (October 1981 through September 1982, fifty-third through fifty-seventh quarters of the Program). The new CEEE Technical Progress Bulletin replaces the Progress Briefs series [single copies of 82-2636 are available from the Center, see back cover for address].

Center sponsors: The Center Programs are sponsored by the National Bureau of Standards and a number of other organizations, in both the Federal and private sectors; these are identified on page 14.

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SEMICONDUCTOR TECHNOLOGY PROGRAM

Silicon Materials

Recently Published

Baghdadi, A., **Implicit Apodization of Interferograms in Fourier Transform Spectroscopy**, Applied Spectroscopy, 37, No.6, pp. 520-523 (June 1983).

The removal of secondary and tertiary interferograms from the main interferogram in Fourier transform spectroscopy can lead to an implicit apodization of the specimen interferogram. This effect can result in the generation of unwanted artifacts in the specimen's transmittance or absorption spectrum. One approach for avoiding this problem is to use an apodization function on the background and reference interferograms which matches the function used on the specimen interferogram.
[(301) 921-3625]

Lowney, J.R., Larrabee, R.D., and Thurber, W.R., **The Relationship Between Deep-Level Measurements and Lifetime in Devices**, Proc. 1983 Custom Integrated Circuits Conf., Rochester, NY, May 23-25, pp. 152-156 (1983).

The minority-carrier lifetime in silicon devices affects performance by influencing such lifetime-related quantities as switching times, storage times, and reverse-leakage currents. A computer program has been developed to model the behavior of deep-level recombination centers that control the minority-carrier lifetime. The input parameters that characterize the deep levels can be measured by capacitive-transient techniques coupled with a measurement of the low-injection level lifetime. These parameters can be used for deep-level identification and diagnostic purposes and, as input to the program, for predicting lifetime under different injection-level conditions. This technique of deep-level characterization is illustrated for $\underline{n}^{+}\underline{p}$ and $\underline{p}^{+}\underline{n}$ diodes containing deep levels from intentionally added platinum.
[(301) 921-3786]

Phillips, W.E. and Lowney, J.R., **Analysis of Nonexponential Transient Capacitance in Silicon Diodes Heavily Doped with Platinum**, J. Applied Physics 54, pp. 2786-2791 (May 1983).

An analysis having improved rigor has been made of the capacitance transient in a space charge layer due to thermal emission from charged defect centers in a semiconductor depletion region. This analysis extends the range of applicability of capacitance-transient defect characterization techniques to nonexponential transient conditions such as found in heavily doped diodes or when defect centers are charged in only a part of the depletion region. An example of the improvement is shown for three silicon diodes heavily doped with platinum.
[Contact: Lowney, (301) 921-3786]

Integrated Circuit Test Structures

Approved for Publication

Cassard, J.M., **A Sensitivity Analysis of SPICE parameters Using an Eleven-Stage Ring Oscillator**, to be published in special joint issue of IEEE Trans. Electron Devices and the IEEE J. Solid State Circuits [companion paper describing first phase of work given at 1983 Custom Integrated Circuits Conference, Rochester, NY, May 23-25, 1983 and published in the proceedings of that conference, under the title **The Sensitivity of SPICE Simulations to Input Parameter Variations**, pp. 224-228 (May 1983)].

SPICE is a circuit simulator which predicts node voltages and currents as a function of time from device model parameters. Model parameters are affected by the manufacturing process. Process-

Integrated Circuit Test Struc., cont'd.

induced variations in these parameters occur within a chip or from chip to chip and cause corresponding variations in circuit performance. Values for the model parameters used in simulators are usually obtained from test structures which are found along the periphery of the circuit or in test chips located at several sites on the product wafer. Because of the spatial separation between test structures and the circuits of interest, differences between measured and simulated performance can occur. This paper presents examples of how well input parameters extracted from a test chip can predict the ac response of a dynamic circuit element on the same wafer. Simulation results show which model parameters are critical to performance. A comparison of measurement and simulation results is given and the importance of intra-chip and intra-wafer parameter variations is discussed. For the samples tested, the polysilicon gate linewidth variation was determined to be the primary cause of the ring oscillator frequency variation.
[(301) 921-3621]

Recently Published

Mazer, J.A., Linholm, L.W., Pramanik, D., Tsai, S., and Saxena, A.N., **Effects of Phosphorus Contact Doping and Sheet Resistance Variations on Al/Si Interfacial Contact Resistance**, Proc. Custom Integrated Circuits Conf., Rochester, NY, May 23-25, pp. 291-294 (1983).

A microelectronic test structure and electrical measurement method for the determination of interfacial contact resistance R_C and interfacial contact layer uniformity are described. This test structure and method are used to investigate the effects of phosphorus-contact doping and sheet resistance variations on R_C and on interfacial layer uniformity. Measurement results indicate that phosphorus-contact doping lowers the value of R_C by as much as a factor of two without sacrificing the uniformity of the interfacial layer. The specific contact resistance ρ_C is shown to be approximately directly proportional to the sheet resistance of the silicon in the contact window.
[(301) 921-3621]

Russell, T.J., **Description of a CMOS Test Chip, NBS-39**, NBSIR 83-2683 (April 1983).

Test chip NBS-39 was designed to analyze the scaling properties of short-channel metal oxide-semiconductor field effect transistors (MOSFETs). This report is a guide for identifying and locating each test structure included on the test chip. There is a table with each test structure identified by name, number, parameter measured, and a reference of how to perform the measurement when appropriate. The test chip can be fabricated by a junction-isolated (JI) silicon complementary metal oxide semiconductor (CMOS) p-well process and by a local oxidation of silicon (LOCOS) CMOS p-well process. The modifications required to go from a JI-CMOS fabrication process to a LOCOS-CMOS are discussed.
[(301) 921-3621]

Suehle, J.S., Linholm, L.W., and Kafadar, K., **A Method for Selecting a Minimum Test Chip Sample Size to Characterize Microelectronic Process Parameters**, Proc. Custom Integrated Circuits Conference, Rochester, NY, May 23-25, pp. 308-312 (1983).

A method for determining a test chip sample size to estimate effectively the electrical parameter distributions on an integrated circuit wafer is presented. This method gives relations among sample size and the figure of merit for four statistical techniques (trimmed mean, biweighted mean, median, and arithmetic mean) by which estimates are calculated. To demonstrate the use of this method, it has been applied to the evaluation of a CMOS fabrication process. Measurements on wafers completely patterned with identical test chips were used to

Integrated Circuit Test Struc., cont'd.

determine actual parameter distributions for an entire wafer (true parameter values) Estimates of true parameters were determined using a site selection plan which is representative of sampling plans employed in industry. The above four statistical techniques were used to compute estimates for electrical parameters and their respective figures of merit. These estimates were compared with the true parameter values determined from testing all test chips on the wafer. When this method is used in conjunction with the cost criteria for test chip sample size, it enables judgments to be made on the effectiveness of sampling strategies for various processes and process technologies. The results reported in this paper for CMOS processes are interpreted for the case when no sample size cost criteria are given. [(301) 921-3621]

Process and Device Modeling

Released for Publication

Brodfuehrer, B.P., Galloway, K.F., and Wilson, C.L., **Comparison of Simple Approximations and Numerical Solutions for the Threshold Voltage of Ion-Implanted Long-Channel MOSFETs,** submitted to IEEE Trans. Education.

The very simple approximations used for calculating the threshold voltage shifts for ion-implanted long-channel MOSFETs in classroom discussions are compared with the results of a more exact numerical simulation. Limited experimental measurements are compared with the calculated threshold voltage shifts.

Recently Published

Albers, J., Wilson, C.L., and Blue, J.L., **Effect of Surface Beveling on Carrier Profiles,** Extended Abstracts of the Electrochemical Society, Vol. 83-1, pp. 641-642 (1983) [paper given at Society meeting at San Francisco, CA, May 8-13, 1983].

The two-dimensional potential distribution is calculated for a beveled structure by means of finite-element techniques. The calculations are presented for several forms of the dopant distribution as well as a number of choices of the surface recombination velocity. The effects of both of these variables on the location of the electrical junction are presented with particular attention to the implications of electrical profile measurements. The principal result of this calculation is that the total depletion width goes to zero where the junction intersects the beveled surface. [(301) 921-3621]

Berkowitz, H.L. and Albers, J., **The Relation Between Two-Probe and Four-Probe Resistances on Nonuniform Structures,** Extended Abstracts of the Electrochemical Society, Vol. 83-1, pp. 622-623 (1983) [paper given at Society meeting at San Francisco, CA, May 8-13, 1983].

A general relation between the two-probe resistance and the four-probe resistance on nonuniform structures is derived. Numerical techniques are presented and discussed for the evaluation of the equations for nonuniform structures. The relation between the four-probe resistance and the incremental sheet resistance is shown to arise in the limit as the probe spacing becomes large compared to the distance to an insulating boundary. Also presented is a method for the self-consistent calibration of spreading resistance profiles. [(301) 921-3621]

Kahn, A.H. and Lowney, J.R., **Multiple Scattering Theory of the Density of States in Semiconductors,** Solid State Communications, 46, No. 3, pp. 229-233 (May 1983).

A method for calculating the electronic density of states of a semiconductor in the presence of impurity scattering is given. The approach is based on a low

Process and Device Modeling, cont'd.

density multiple scattering expansion. The calculation treats the density of states of the conduction band, shifts of the band edge, and the profiles of the impurity bands. It is performed for a simple model, using a spherical well potential for the individual impurity centers, but could be extended to any scattering potential. The first impurity band forms when the potential is sufficiently strong that one center can bind an electron. The impurity bands are of finite width, have a flat upper edge, and an asymmetrically broadened tail on the low energy side.
[(301) 921-3786]

Power Devices

Recently Published

Chen, D.Y., Lee, F.C., Blackburn, D.L., and Berning, D.W., **Reverse-Bias Second Breakdown of High Power Darlington Transistors**, Proc. 1983 Power Conversion International Conf., Orlando FL, April 19-21, pp. 15-25 (1983) [also submitted to IEEE Trans. Aerospace and Electronic Systems].

The reverse-bias second breakdown, RBSB, characteristics of high power Darlington transistors are discussed. The Darlingtons investigated are rated at 400 V maximum voltage and 100 A maximum current. Devices both with and without speed-up diodes (connected between the bases of the input and output transistor) were studied. A nondestructive system for characterizing the RBSB behavior of these devices is described. The RBSB behavior was found to vary in an unpredictable manner with varying reverse base current magnitude. It was also found that the RBSB behavior of the Darlingtons was a function of the forward base current magnitude. This is in marked contrast to what has been found for discrete devices. The presence of a speed-up diode also influenced the RBSB behavior of these devices.
[(301) 921-3541]

Packaging

Recently Published

Zimmerman, D.D. and Schafft, H.A., **VLSI Package Reliability Workshop Report**, 21st Annual Proc., Reliability Physics 1983, pp. 310-232 [Reliability Physics Symposium, Phoenix, AZ, April 5-7, 1983].

This report summarizes remarks made by six panelists in an evening workshop meeting held as part of the 1983 International Reliability Physics Symposium. The panelists provided an overview of package design and measurement considerations that arise because of special requirements of packaging VLSI semiconductor chips. Considerations in the following areas were discussed: package materials, design, and construction; thermal management and characterization and moisture and hermeticity measurements.
[Contact: Schafft, (301) 921-3621]

Other Semiconductor Metrology

Approved for Publication

Dodge, M.J., **Refractive Properties of Magnesium Fluoride**, submitted to Applied Optics.

The refractive indexes of a commercially available specimen of single-crystal MGF_2 were determined for both the ordinary and extraordinary rays at selected wavelengths from 0.2026 to 7.04 μm. Measurements were made by means of the minimum-deviation method on a precision spectrometer near 19°C. The experimentally determined index values for each polarization were fitted to a three-term Sellmeier-type dispersion equation of the form:

$$n^2 - 1 = \Sigma A_j \lambda^2 / (\lambda^2 - \lambda_j^2),$$

relating the refractive index n to the wavelength of interest λ, the calculated

Other Semiconductor Metrology, cont'd.

wavelength A_j. The birefringence was computed as a function of wavelength from the calculated index values obtained for the two polarizations. The dispersion coefficients were also determined for the O-ray and for the birefringence. The results of this study are compared with previously reported work on the refractive properties of MgF_2.
[(301) 921-3625]

Recently Published

Baylies, W.A., Scace, R.I., and Vieweg-Gutberlet, F., **International Standards for Semiconductor Materials,** ASTM Standardization News, 11, No. 5. pp. 21-23 (May 1983).

Semiconductor silicon is an internationally traded commodity which requires sophisticated characterization procedures for producer's quality control and purchaser's incoming inspection tests. International coordination at the technical committee level, being pursued by ASTM Committee F-1 on Electronics, to create a technically consistent set of test methods throughout the world is described. Some further topics for international collaboration in test method development are also mentioned.
[Contact: Scace, (301) 921-3786]

FAST SIGNAL ACQUISITION, PROCESSING, AND TRANSMISSION

Cryoelectronic Metrology

Recently Published

Hamilton, C.A., **100 GHz Binary Counter Using SQUID Flip Flops,** Proc. Applied Superconductivity Conf., November 30 - December 3, 1982, IEEE Trans. Magnetics, MAG-19, No. 3, pp. 1291-1292 (May 1983) [abstract appeared on page 11 of July 1983 TPB (NBSIR 83-2719-3)].

Hamilton, C.A. and Lloyd, F.L., **8-Bit Superconducting A/D Converter,** Proc. Applied Superconductivity Conf., November 30 - December 3, 1982, IEEE Trans. Magnetics, MAG-19, No. 3, pp. 1259-1261 (May 1983) [abstract appeared on page 12 of July 1983 TPB (NBSIR 83-2719-3)].

Harris, R.E. et al., **Microwave Mixing and Direct Detection Using SIS and SIS' Quasiparticle Tunnel Junctions,** Proc. Applied Superconductivity Conf., November 30 - December 3, 1982, IEEE Trans. Magnetics, MAG-19, No. 3, pp. 490-493 (May 1983).

Quasiparticle mixers have shown strong quantum effects, conversion gain and noise levels approaching the quantum limit, but only in tunnel junctions with very low sub-gap "leakage" conductance. It has been suggested that SIS' tunnel junctions, made from two different conductors with unequal gaps, will function as high-gain mixers since the dynamic conductance below the gap is negative. We report results of the first SIS' mixing and direct detection experiments. At 36 GHz, a conversion efficiency of -4 dB with a noise temperature of 33 K (SSB) has been obtained. A novel gain mechanism for SIS' direct detectors is predicted. A direct detector responsivity of 250 A/W was measured. We compare our results to quantum theory models. In addition, we demonstrate quasiparticle harmonic mixing of a 36-GHz signal with an 18-GHz local oscillator in tin SIS junctions. Harmonic mixers offer significant advantages at high micro-wave frequencies at which sufficient local oscillator power may not be available.
[(303) 497-3776]

Kautz, R.L., **Chaos in Josephson Circuits,** Proc. Applied Superconductivity Conf., November 30 - December 3, 1982, IEEE Trans. Magnetics, MAG-19, No. 3, pp. 465-473 (May 1983) [abstract appeared on page 12 of July 1983 TPB (NBSIR 83-2719-3)].

Cryoelectronic Metrology, cont'd.

Kautz, R.L., **Operation of a Superconducting Analog-to-digital Converter at Short Conversion Times**, Proc. Applied Superconductivity Conf., November 30 - December 3, 1982, IEEE Trans. Magnetics, MAG-19, No. 3, pp. 1186-1189 (May 1983) [abstract appeared on page 12 of July 1983 TPB (NBSIR 83-2719-3)].

VanZeghbroeck, B.J., **Superconducting Current Injection Transistor**, App. Phys. Lett. 42(8), pp. 736-738 (April 1983) [abstract appeared on page 12 of July 1983 TPB (NBSIR 83-2719-3)].

Antenna Metrology

Recently Published

Hill, D.A., **Book Review - Leaky Feeders and Subsurface Radio Communications**, IEEE Antennas and Propagation Society Newsletter, Vol. 25, No. 3, pp. 23-24 (June 1983) [abstract appeared on page 13 of July 1983 TPB (NBSIR 83-2719-3)].

Yaghjian, A.D., **Approximate Formulas for the Far Fields and Gain of Open-Ended Rectangular Waveguide**, NBSIR 83-1689, May 1983.

Approximate formulas are derived for the far field and gain of standard, open-ended, unflanged, rectangular waveguide probes operating within their recommended usable bandwidth of frequencies. (Such probes are commonly used in making probe-corrected near-field antenna measurements.)

The formulas, which yield forward far-field power patterns and on-axis gains of X-band and larger waveguide probes to within about 2 dB and 0.2 dB accuracy, respectively, assume $(\sin\phi - \cos\phi)$ azimuthal angular dependence and an E-plane pattern given by the traditional aperture integration of the TE$_{10}$ mode E-and H-fields in the Stratton-Chu equations. The H-plane pattern is estimated by two different methods. The first, and less accurate, method uses a purely E-field aperture integration to estimate the H-plane pattern. The second, more accurate, method uses an electric field integral equation (EFIE) to show that fringe currents near the shorter edges of the guide can be well-approximated by isotropic line sources. The amplitude of these line sources is then determined more simply by equating the total power radiated into free space to the net input power to the waveguide.
[(303) 497-5484]

Microwave & Millimeter-Wave Metrology

Recently Published

Engen, G.F., **Redundance: A Monitor of Six-Port Performance**, U.K. Institute of Electrical Engineers 1983 Colloquium on Advances in S-Parameter Measurement at Microwave Lengths, May 23, 1983, Savoy Place, London WC2B0BL, pp. 4/1-4/2 (1983).

By almost any standard of comparison, today's automated network analyzers represent a highly complex and sophisticated measuring instrument, with its own set of maintenance problems and potential failure modes. While certain types of malfunctions are immediately evident to the operator, there may be others whose effect is less obvious.

One of the more interesting features of the six-port network analyzer is that its response is "overdetermined" in the sense that four (scalar) detectors are employed to obtain three pieces of information -- namely the emergent wave amplitude and the complex reflection coefficient as they exist at the measurement port. With proper interpretation, this additional piece of information can be used, not only to improve the overall accuracy, but also as a continuous monitor of the system performance, and to flag a very large fraction of potential malfunctions. (While some reference to this feature has been made

Microwave & Millimeter-Wave, cont'd.

in earlier papers, it apparently is still not fully appreciated by the microwave community).
[(303) 497-3511]

Laser Metrology

Recently Published

Sanders, A.A., **Laser Measurements,** Proc. 1983 Measurement Science Conf., Palo Alto, CA, January 20-21 (June 1983).

This talk will review some of the national standards and measurement services for lasers available at NBS, highlight some of the current research, and indicate some of the future needs and direction of NBS laser metrology research.
[(303) 497-5341]

Optical Fiber Metrology

Recently Published

Gallawa, R.L., Chamberlain, G.E., Day, G.W., Franzen, D.L., and Young, M., **Measurement of Multimode Optical Fiber Attenuation: An NBS Special Test Service,** NBS Technical Note 1060, (June 1983) [abstract appeared on page 15 of July 1983 TPB (NBSIR 83-2719-3)].

Gallawa, R. and Franzen, D.L., **EIA Fiber Performance Measurement Standards,** Photonics Spectra, pp. 55-68 (April 1983).

This paper reviews optical waveguide test procedures and techniques that are approved by, or in review for, the Electronics Industries Association (EIA). We concentrate on those procedures and documents to which we have been a party, either directly or indirectly. In particular, we discuss a glossary of terms, fiber attenuation, fiber bandwidth, and refractive index profile, the last of which leads to a determination of core diameter. [(303) 497-3761]

Kim, E.M. and Franzen, D.L., **Two-Dimensional Near-Field Contouring of Optical Fiber Cores,** Proc. SPIE -- The International Society of Optical Engineering (June 1983) [abstract appeared on page 8 of May 1983 TPB (NBSIR 83-2719-2)].

Other Fast Signal Topics

Recently Published

Danielson, B.L., **Optical Time-Domain Reflectometer Performance and Calibration Studies,** NBS Technical Note 1065 (June 1983).

The measurement accuracy of the optical time-domain reflectometer (OTDR) is restricted in some applications by a limited operational dynamic range and by a lack of standardized test procedures. In an effort to better understand these restrictions, we have measured the range of linearity of some avalanche photodiodes used as backscatter detectors. Also, the effect of input launch conditions is examined and a possible standardized OTDR test procedure is proposed. Using these suggestions, we have made comparisons between attenuation values determined by cutback and backscatter methods and found that good agreement is possible. Finally, some methods are described for checking the response linearity of OTDR systems.
[(303) 497-5620]

ELECTRICAL SYSTEMS

Power Systems Metrology

Released for Publication

Hillhouse, D.L., **NBS Experience, Field Calibration of CCVTs,** Proc. Workshop on Metering Accuracy CCVTs, June 2-3, 1983, to be published by Electric Power Research Institute.

Since its completion in 1976, the EPRI-NBS field calibration system for coupling capacitor voltage transformers

Power Systems Metrology, cont'd.

(CCVTs) has been in NBS custody and has been used in field calibrations at six utilities. Measurements have been performed on 61 CCVTs, including 51 of metering class (12 of which were not using the X1X3 metering tap) and on nine metering VTs. This paper discusses the measurements at the six utilities, and summarizes all zero burden and connected burden results on metering windings. A large proportion of these CCVTs were found to be out of metering tolerance at both zero and connected burdens. However, the data base is not large enough to allow extension of these results to metering CCVTs in general.
[(301) 921-3121]

Hillhouse, D.L., **The EPRI-NBS CCVT Calibration Systems,** Proc. Workshop on Metering Accuracy CCVTs, June 2-3, 1983, submitted to Electric Power Research Institute (EPRI).

This paper describes briefly a prototype system for field calibration of CCVTs developed by NBS in EPRI project RP-134-1, and in more detail, a simplified, less costly system developed later with partial support from the Pennsylvania Power and Light Co. The latter system was breadboarded as part of the above EPRI project.

The prototype system contains five major dedicated components: (1) a current-comparator bridge, (2) a modular capacitive transfer standard divider, (3) a compressed-gas standard capacitor, (4) a resonant power supply and (5) a calibration truck. Its field accuracy is estimated to be 0.1% and 0.3 mrad, but it would be very expensive to reproduce.

The simplified system contains only three major components: (1) the transfer standard divider mentioned above, (2) a voltage comparator, and (3) a combined standard-power transformer module. The latter two items represent much lower cost and weight than those of items (2), (3), and (4) in the prototype system, which they replace. The dedicated truck could then be eliminated as well, and the entire system transported to the field in a non-dedicated truck and a van. The accuracy of the simplified system is comparable to that of the prototype.
[(301) 921-3121]

McKnight, R.H., **Measurements of DC Electric Fields and Ion Related Quantities,** submitted to Proc. Conference on Environmental Ions and Related Biological Effects.

Measurement techniques developed by atmospheric scientists for characterizing the earth's electrical environment are useful for measuring various electrical parameters near high voltage dc (HVDC) transmission lines. Parameters of primary interest are the electric field, vertical current density, and polar space charge density. Other quantities which have been measured include conductivity, net space charge density, and the mobility spectrum of ions making up the space charge.

Errors associated with the various measurements are discussed, including those which result from the high electric fields and space charge densities existing near the lines. In addition, these measurement techniques are being used to characterize the operation of biological exposure systems.
[(301) 921-3121]

McKnight, R.H. and Fulcomer, P.M., **Operation of Ion Counters Near High Voltage DC Transmission Lines,** submitted to Proc. Fourth International Symposium on High Voltage Engineering.

Measurements of electrical quantities such as electric field, vertical current density, and space charge density are necessary to characterize the electrical environment around high voltage dc transmission lines. Ion counters are used to measure space charge densities. A monopolar line has been used in the laboratory to study the effects of

Power Systems Metrology, cont'd.

external electric fields on the operation of ion counters located above ground. Space charge densities were determined as functions of counter air flow, electrical potential, and inlet geometry. The effects of counter potential were not large until the potential was approximately equal to that of the space potential near the counter, when the indicated ion density dropped significantly. A dependence of flow rate was observed, which appears to be due to the large external electric fields existing at the inlet to the ion counter causing a loss of ions to the counter walls at lower flow rates.
[(301) 921-3121]

Misakian, M. and Fulcomer, P.M., **Measurement of Nonuniform Power Frequency Electric Fields,** submitted to IEEE Trans. Electrical Insulation.

The performance of free-body electric fieldmeters which have been calibrated for use in nearly uniform power frequency electric fields is examined under nonuniform field conditions. Theoretical and experimental results are presented which indicate that measurements can be made with small error.
[(301) 921-3121]

Recently Published

Hebner, R.E., **Development of Power System Measurements -- Quarterly Report July 1, 1982 to September 30, 1982,** NBSIR 83-2705 (May 1983).

This report documents the progress of four technical investigations sponsored by the Department of Energy. Three were performed by the Electrosystems Division, the National Bureau of Standards and the fourth by the Department of Electrical Engineering of the University of Southern California. The work described covers the period from July 1, 1982 to September 30, 1982. The report emphasizes the calibration of instruments designed to measure the 60-Hz electric field in biological exposure facilities, the determination of the role of photodetachment of SF_6 corona discharges, the measurement of failure mechanisms in liquid/solid insulating systems, and the development and behavior of active insulators.
[(301) 921-3121]

McKnight, R.H., Kotter, F.R., and Misakian, M., **Measurement of Ion Current Density at Ground Level in the Vicinity of High Voltage DC Transmission Lines,** IEEE Trans. Power Apparatus & Systems PAS-102, No. 4, pp. 934-941 (April 1983).

Sensors for measuring vertical current density at ground level near high voltage dc (HVDC) transmission lines are subject to error when the sensor is not in the ground plane. The magnitude of this error, for guarded and unguarded sensors, has been investigated using both dc electric fields with space charge and ac electric fields in a parallel plate facility. For conditions like those expected under HVDC transmission lines, the results obtained using ac and dc methods agreed to within experimental uncertainty. The measured errors are as large as 25 percent for guarded sensors and significantly larger for unguarded sensors. Data for various sensor elevations and guarding are presented in graphs to aid the designer. Comparisons with results from an IEEE Working Group field day are also presented.
[(301) 921-3121]

Van Brunt, R.J. and Misakian, M., **Role of Photodetachment in Initiation of Electric Discharges in SF_6 and O_2,** J. Applied Physics 54, No. 6, pp. 3074-3079 (June 1983).

The role of photodetachment in the initiation of electron avalanches near a positive point electrode was investigated for a discharge gap in which the negative ion flux was controlled by UV irradiation of the cathode. For irradiation of the anode region with light

Power Systems Metrology, cont'd.

beams up to 500 mW, photodetachment was found to make a negligible contribution to avalanche initiation in SF_6 and O_2 at pressures from 50 to 500 kPA (~0.5 to 5 atm). The conditions under which the role of photodetachment might be observed are discussed, and it is shown that for the conditions considered here the expected dominant electron release mechanism in the gap is through collisional detachment of stable negative ions. Previously reported enhancements in avalanche rates resulting from irradiation of a positive point can be explained as arising from increases in negative ion densities due to attachment of photoelectrons ejected by scattered radiation.
[(301) 921-3121]

Magnetic Materials and Measurements

Recently Published

Cromar, M. and Muhlfelder, B., **Double Transformer Coupling to a Very Low Noise SQUID,** Proc. Applied Superconductivity Conf., IEEE Trans. Magnetics, MAG-19, No. 3, pp. 303-307 (May 1983).

We demonstrate a new way to couple efficiently to a low-inductance, low-noise SQUID. We have built and tested a planar dc SQUID with an integral matching transformer. The measured coupling agrees with our calculations. We demonstrate that this configuration can efficiently couple a 1 μH signal source to a 16 pH SQUID loop. We have also built an uncoupled SQUID of this design that has an energy sensitivity, referred to the SQUID inductor, of 1.3×10^{-32} J/Hz = 20 h over a flux range of about 0.15 ϕ_0.
[(303) 497-5375]

Fickett, F.R. and Goldfarb, R.B., **Magnetic Properties**, Chapter 6 in book, Materials at Low Temperatures, American Society of Metals, Metals Park, OH 44073, pp. 203-235 (June 1983) [abstract appeared on page 18 of July 1983 TPB (NBSIR 83-2719-3)].

Superconductors

Recently Published

Ekin, J.W., **Effect of Stainless Steel Reinforcement on the Critical Current Versus Strain Characteristic of Multifilamentary Nb_3Sn Superconductors**, J. Applied Physics 54 (5), pp. 2869-2871 (May 1983) [abstract appeared on page 14 of May 1983 TPB (NBSIR 83-2719-2)].

Ekin, J.W., **J-B-T-ε Interaction in A15, B1, and C15 Crystal Structure Superconductors**, Proc. Applied Superconductivity Conf., IEEE Trans. Magnetics, MAG-19, No. 3, pp. 900-902 (May 1983) [abstract appeared on page 18 of July 1983 TPB (NBSIR 83-2719-3)].

Ekin, J.W., **Superconductors**, Chapter 13 in book, Materials at Low Temperatures, American Society of Metals, Metals Park, OH 44073, pp. 465-513 (June 1983) [abstract appeared on page 13 of May 1983 TPB (NBSIR 83-2719-2)].

Fickett, F.R., **Oxygen-Free Copper at 4K**, Proc. Applied Superconductivity Conf., IEEE Trans. Magnetics MAG-19, No. 3, pp. 228-231 (May 1983) [abstract appeared on page 18 July 1983 TPB NBSIR 83-2719-3)].

Gavaler, J.R., Greggi, J., Wilmer, R., and Ekin, J.W., **Properties of NbN Films Crystallized from the Amorphous State**, Applied Superconductivity Conf., IEEE Trans. Magnetics, MAG-19, No. 3, pp. 418-421 (May 1983) [abstract appeared on page 18 of July 1983 TPB (NBSIR 83-2719-3)].

Goodrich, L.F., **The Effect of Field Orientation on Current Transfer in Multifilamentary Superconductors**, Proc. Applied Superconductivity Conf., IEEE Trans. Magnetics, MAG-19, No. 3, pp. 244-247 (May 1983) [abstract

Superconductors, cont'd.

appeared on page 18 of July 1983 TPB (NBSIR 83-2719-3)].

Hong, M., Hull, G.W., Jr., Holthuis, J.T., Hazzenzahl, W.V., and Ekin, J.W., **Multi-filamentary Nb-Nb_3 Composite by Liquid Infiltration Method: Superconducting, Metallurgical, and Mechanical Properties**, Proc. Applied Superconductivity Conf., IEEE Trans. Magnetics, MAG-19, No. 3, pp. 912-916, (May 1983) [abstract appeared on page 19 of July 1983 TPB (NBSIR 83-2719-3)].

Other Electrical Systems Topics

Recently Published

Clark, A.F., **Thermal Expansion**, Chapter 3 in book, Materials at Low Temperatures, Eds. R. Reed and A.F. Clark, American Society for Metals, Metals Park, OH 44073, pp. 75-132 (June 1983).

The thermal expansion behavior of materials at low temperature is reviewed. The tutorial chapter describes the theory, experimental methods, typical data, and sources and applications of data for thermal expansion. Materials covered are metals and alloys, nonmetallic compounds, glasses and ceramics, polymers, and composites.
[(303) 497-3253]

Fickett, F.R., **Electrical Properties**, Chapter 5 in book, Materials at Low Temperatures, Eds. R. Reed and A.F. Clark, American Society for Metals, Metals Park, OH 44073, pp. 163-201 (June 1983).

This chapter gives a review of the electrical properties of materials at cryogenic temperatures. Measurement techniques, the data base, and uses of the data are presented. The emphasis is on metals and alloys of technological importance; a topic which covers a large range of materials. The treatment of theory and of measurement techniques is primarily for the user interested in the more practical aspects. In every instance, however, extensive references are given that allow the reader to pursue the subject further. The text is essentially that of NBS Technical Note 1053 with minor modifications.
[(303) 497-3785]

ELECTROMAGNETIC INTERFERENCE

Recently Published

Kanda, M., **An Electric and Magnetic Field Sensor for Simultaneous Electromagnetic Near-Field Measurements - Theory**, NBS Technical Note 1062 (April 1983).

This paper describes the theory of a single sensor to perform simultaneous electric and magnetic near-field measurements. The theory indicates that it is possible to obtain the magnetic-loop and electric-dipole currents using a loop terminated with identical loads at diametrically opposite points. The theory also indicates that it is possible to obtain an ideal load impedance for achieving equal electric and magnetic field responses of the loop. Preliminary experiments have been performed using plane waves to verify these results.
[(303) 497-5320]

Kanda, M. and Ries, F.X., **Time Domain Sensors for Radiated Impulsive Measurements**, IEEE Trans. Antennas and Propagation, AP-31, No. 3, pp. 438-444 (May 1983) [also given as paper by Kanda and Ries at the IEEE 1982 International EMC Symposium, Santa Clara, CA, September 8-10, 1982, pp. 296-301; abstract appeared on page 5 of May 1983 TPB (NBSIR 83-2719-2)].

Ma, M.T. and Koepke, G.H., **Uncertainties in Extracting Radiation Parameters for an Unknown Interference Source Based on Power and Phase Measurement**, NBS Technical Note 1064 (June 1983).

Electromagnetic Interference, cont'd.

A method for determining the radiation characteristics of a leaking interference source has been reported in a previous publication, in which the unintentional, electrically small leakage source was modeled by two vectors representing a combination of equivalent electric and magnetic dipole moments. An experimental setup, measurement procedures, and the necessary theoretical basis were all described therein to explain how the relevant source parameters can be extracted from the measurement data of output powers and phases taken when the interference source is placed inside a transverse electromagnetic (TEM) cell. Simulated examples were also given to show that the equivalent source parameters of unknown vector dipole moments and, thus, the detailed radiation pattern and the total power radiated by the source in free space could be uniquely determined by the method if the measurement data were not contaminated by noise. This report presents the mathematical analysis of the uncertainties in the final, extracted results when the experimental data are degraded by the background noise and measurement inaccuracies.
[(303) 497-3800]

CEEE CALENDAR

1984

April 30 - May 4 (Boulder, CO)

NBS Noise Measurement Seminar. The course is intended for practicing noise metrologists and technical managers responsible for systems for which accurate noise measurements are important. The seminar introduces and describes reference noise sources, noise measuring systems, and the problems of characterizing and measuring noise in passive components, amplifiers, and satellite earth terminals. Class examples will specifically address the measurement of noise power; amplifier noise; and antenna system noise, including measures such as noise equivalent flux, the ratio of system gain to system noise temperature G/T, and the ratio of carrier power to noise density C/kT.

The course will cover both theory and practice of precision noise measurements; the practical lectures are designed to stand alone and to be understood by those having minimal mathematical background.
[Contact: Sunchana Perera (303) 497-3546]

June 18-21 (Gaithersburg, MD)

Power Electronics Specialists Conference. Co-sponsored by the National Bureau of Standards and the Power Electronics Council of the Institute of Electrical and Electronics Engineers, the Conference is intended to provide a venue where specialists in circuits, systems, electron devices, magnetics, control theory, instrumentation, and power engineering may discuss new ideas, research, development, applications, and the latest advances in power electronics.

The Conference will incorporate six technical sessions (on converter circuits, converter systems, converter control, motor drives, power components, and modeling and analysis techniques), a one-day tutorial on Electromagnetic Compatibility in Power Systems, and three special "rap sessions" (EMI, RFI, and Noise: Fact or Fiction Emerging Power Semiconductors: Positive and Negative Attributes; and Future Trends in Aircraft Power Electronics and Electrical Actuators).
[Contact: Sandra B. Kelley (301) 921-3541]

October 2-3 (Boulder, CO)

Symposium on Optical Fiber Measurements.

CEEE CALENDAR, cont'd.

This symposium, the third in the series of biennial meetings, is co-sponsored by the National Bureau of Standards, the Optical Society of America, and the Optical Waveguide Communications Committee of the Institute of Electrical and Electronics Engineers. Papers have been solicited "for any experimental or analytical aspect of the characterization of optical fibers and fiber optics systems, including attenuation, bandwidth/distortion, dispersion, index profile, cut-off wavelength, mode diameter/core geometry, fiber device (e.g., joint, coupler, multiplexer) evaluation, physical measurements, link parameters (e.g., concatenation), polarization characteristics, system performance, field measurements, and standards."
[Contact: Douglas L. Franzen (303) 497-3346]

NEW STANDARD REFERENCE MATERIALS

Two new Standard Reference Materials (SRMs) for calibrating equipment used to make spreading resistance measurements have been released by the Semiconductor Materials and Processes Division to the NBS Office of Standard Reference Materials for sale to the public. SRM 2526 applies to (111)-oriented p-type silicon surfaces and SRM 2527 to (111)-oriented n-type silicon surfaces. Each SRM consists of a set of about 15 specimens (number of specimens varies depending on availability of material of appropriate resistivities) of silicon, 6 x 12 mm in area and mounted on beveled metal blocks for convenient use in calibrating commercial spreading resistance equipment. These silicon chips have resistivities ranging from about 0.001 to 200 Ω·cm. Slices are measured before dicing; only slices having uniformity of resistivity within predetermined bounds are selected. The uncertainties in resistivity range typically from 2 to 5 percent for p-type specimens and from 4 to 10 percent for n-type. Two companion SRMs for (110) silicon surfaces are about to be released (2528, p-type and 2529, n-type).

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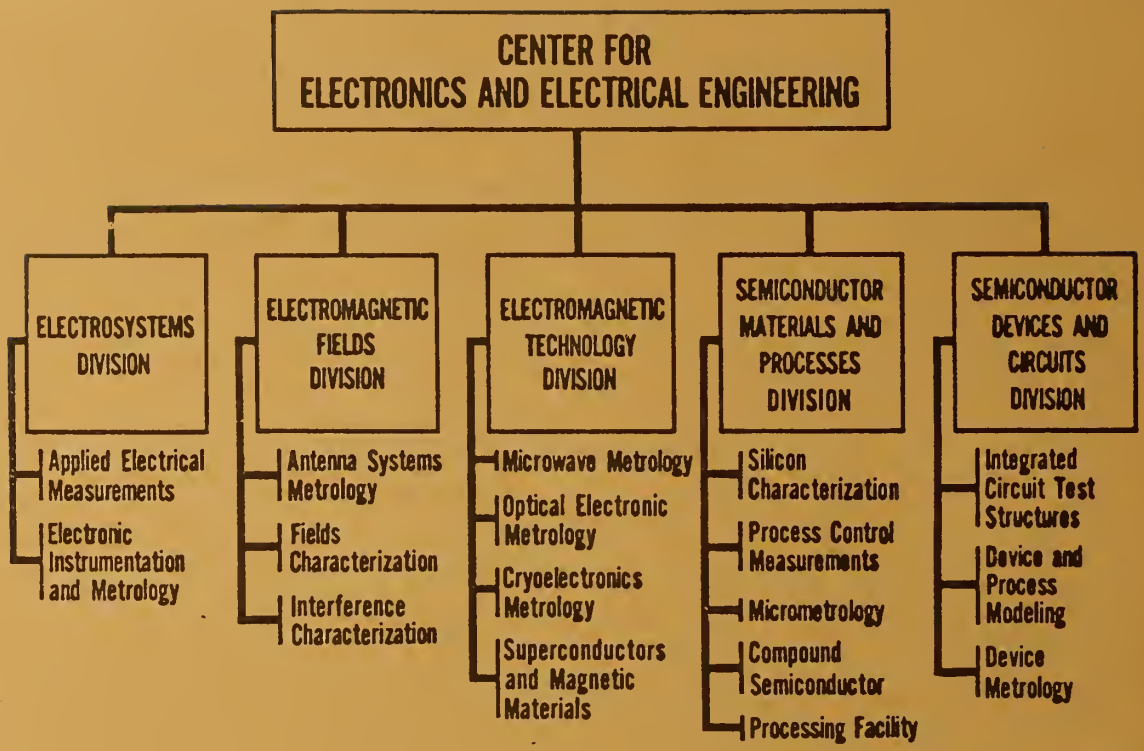

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